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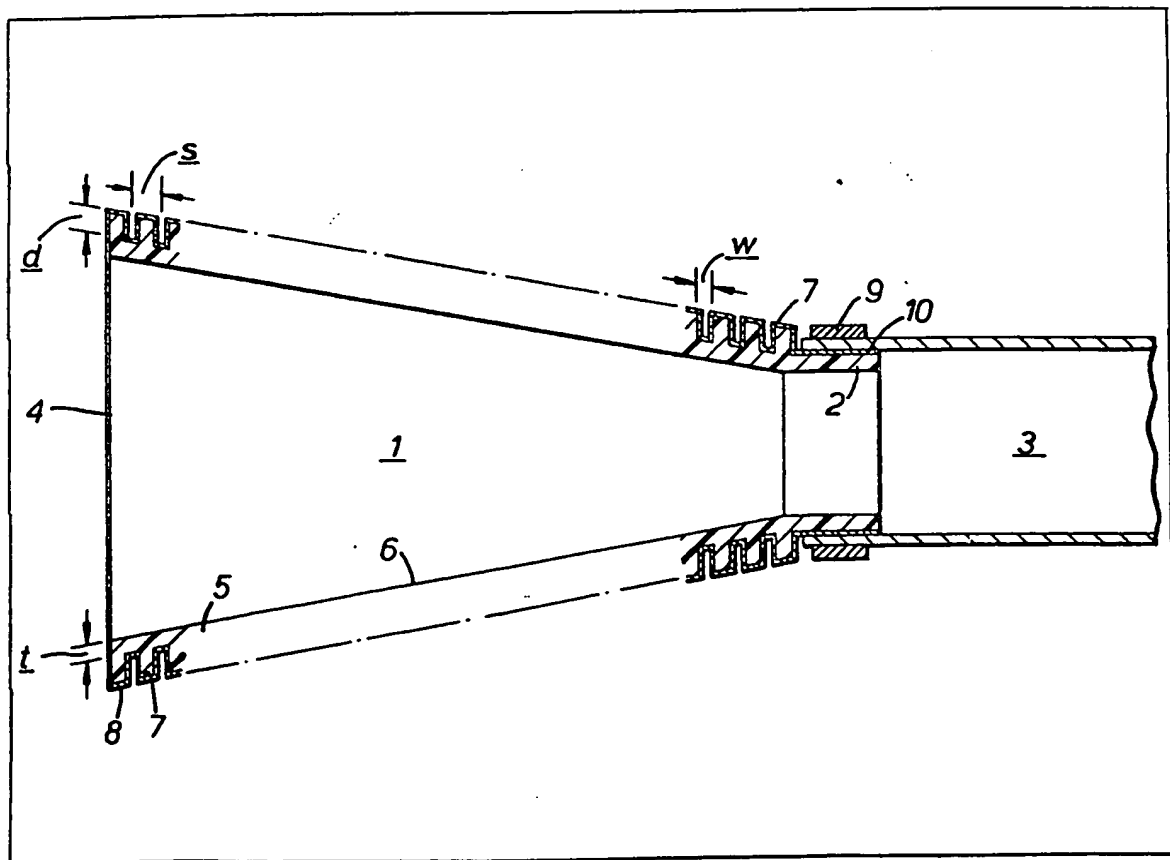
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(54) Electromagnetic horns

(57) A corrugated electromagnetic horn 1 is formed of a loss-less dielectric plastics material 5 which carries the corrugations on its outer surface 7. A layer 8 of copper is formed in contact with the corrugations to constitute the electrically conductive walls of the horn. The corrugations can be machined in a simple manner, since they are readily accessible on the outer surface of the horn. In this way the difficulties generally associated with the manufacture of a corrugated horn,

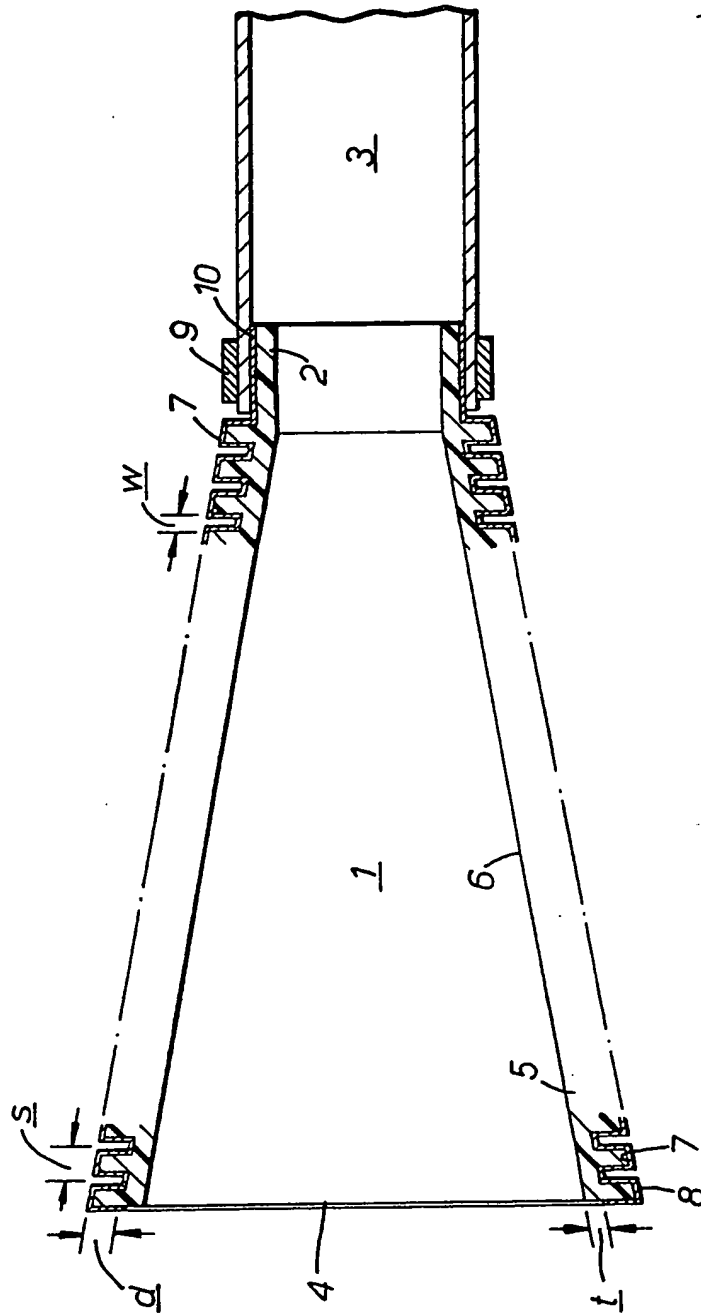
in which corrugations are machined out of solid metal on the rather inaccessible inner surface of the horn, are avoided. The precision with which a horn can be manufactured is therefore greatly increased and furthermore, the resulting product is very much lighter in weight than one machined from solid metal.



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## SPECIFICATION

## Electromagnetic horns

- 5 This invention relates to electromagnetic horns, that is to say, to horns which are capable of launching or receiving electromagnetic wave energy. Electromagnetic horns commonly form part of an antenna arrangement to couple electromagnetic wave energy between an antenna reflecting surface and a waveguide connected to a transmitter and/or receiver. Horns of this kind can also themselves constitute an antenna if suitably shaped, and although electromagnetic horns are usually of a flared shape, they may instead be of constant section, depending on their application and purpose.

- The physical and electrical properties of the horn largely determine the shape of a beam which is transmitted or received by it, and it has been found that the beam profile can be advantageously influenced by providing the internal electrical conducting surface of the horn with grooves or recesses, which are generally termed corrugations. However, it has proved difficult and expensive to machine these corrugations to the required degree of accuracy because of their rather inaccessible position on an internal surface of the horn, and the present invention seeks to provide a corrugated electromagnetic horn in which these difficulties are reduced.

- According to this invention, a corrugated electromagnetic horn includes walls formed of a rigid dielectric material having an externally corrugated surface which supports a thin layer of electrical conductive material in contact therewith.

- The dielectric material is made as thin as possible, consistent with its mechanical strength, so as not to adversely affect the propagation properties of the electromagnetic wave. The external corrugations in the surface of the dielectric material can be readily formed by machining, such as by cutting or grinding. As the external corrugations are clearly visible to an operator there is little difficulty in ensuring that the required accuracy can be met at reasonable cost. Alternatively, the external corrugations could be formed by a plastic extrusion process, depending on the nature of the dielectric material used. Again, because the corrugations are formed on an external surface their accuracy can be readily and simply verified.

- Subsequently, a thin layer of electrical conductive material, such as copper, is deposited on to the external corrugations to constitute the outer electrical wall of the horn. The inner profile of the conductive material is thus determined wholly by the previously formed corrugations. Generally the thickness of the conductive layer will not be great since the r.f. currents circulating in the conductive material

will be fairly low, but where the external corrugations are narrow, the conductive material may partially, or completely, fill them.

- The invention is further described by way of example with reference to the accompanying drawing, which illustrates a section view of a corrugated horn in accordance with this invention.

- Referring to the drawing, an electromagnetic corrugated horn 1 is connected at one end 2 to a circular waveguide 3. The horn is of circular cross-section, and is flared outwards towards its free end 4.

- In alternative configurations (not shown) the horn may be of elliptical, square or rectangular etc., shape in cross-section, and the taper of the flare can be curved rather than straight, and in some circumstances the horn may be of constant cross-sectional size along part or the whole of its length.

- In use, the waveguide 2 would be connected to a microwave transmitter or receiver, and the open end 3 would typically be directed towards the reflecting surface of an antenna, or the open end 3 may itself constitute a radiating element.

- The horn 1 consists of a rigid conical dielectric former 5 having a smooth internal surface 6 and a corrugated external surface 7. The corrugations consist of a series of closed circular ring-like grooves or recesses although alternatively a single groove in the form of a helical spiral could be provided, but this latter configuration is more difficult to produce. The corrugated surface 7 is provided with a thin layer 8 of copper formed in contact therewith, and this layer 8 constitutes the outer electrical surface of the horn. The horn 1 is mounted in contact with the waveguide 3, so that the layer 8 makes electrical contact with the electrically conductive walls of the waveguide. Conveniently, a tensioned band of material is arranged to constitute a clamp 9, which compresses the outer end of the waveguide 3 to hold it in close contact with a rim 10 which is formed as an extension of the layer 8.

- The number of corrugations present along the length of the horn will depend on the frequency of the microwave signals which are to be transmitted or received, and on the overall physical length of the horn. Typically, adjacent corrugations are spaced apart by a distance which is less than one third of the wavelength of the microwave signal, and preferably the spacing  $s$  is much less than this. The corrugations advantageously influence the profile of the electromagnetic beam which is formed by the horn, by equalising the boundary conditions for the electric and magnetic fields associated with the electromagnetic wave. In order to provide the correct effect, the depth  $d$  of the corrugations is typically one quarter of a wavelength of the electromagnetic wave in the dielectric material. In the absence of the dielectric material, the

depth of the corrugations would be determined wholly by the free-space value of the wavelength of the microwave signal (or of the centre frequency, if a band of signals is present), but in the present case the depth of the corrugations is less than that by a factor of approximately  $\sqrt{\epsilon_r}$ , where  $\epsilon_r$  is the relative permittivity of the dielectric material. The thickness  $t$  of the dielectric material between the base of the corrugation and its internal surface is preferably kept as small as possible. Advantageously the dielectric material has a low dielectric constant and is substantially lossless - i.e. it does not significantly absorb microwave energy. The dielectric material can conveniently be a plastics material which is easily machined, but alternatively a glass fibre material could be used although such a material is not entirely lossless.

20 The corrugated electromagnetic horn illustrated in the drawing is formed by taking a solid block of plastics material having a suitable dielectric constant, and by machining its internal and external surfaces to produce a thin walled hollow body in the shape of a truncated cone. Subsequently, the external corrugations are machined away by means of a lathe or the like, to the required degree of accuracy to leave as smooth a surface as possible. The thin layer 8 of copper is then deposited on to the outer corrugated surface by any convenient conventional process, such as electroless deposition or vapour deposition, to a thickness of about 0.1 mm.

35 If the width  $w$  is very small the corrugations may be partly or wholly filled by the copper. Under some circumstances, it may be desirable to deliberately fill the corrugations in this way, so that the outer surface of the horn has a relatively smooth appearance.

40 When completed, the horn is offered up to the end of the waveguide 3 and clamped in position. Alternatively, it can be permanently fixed to the waveguide 3 by the use of an electrically conductive bond - such as a silver loaded adhesive.

45 The horn has the advantage of being capable of being made to high precision in a relatively economical manner. In addition, since the bulk of it is formed of a plastics material, it is very light indeed compared to a horn which has been machined from a solid block of metal.

## 55 CLAIMS

1. A corrugated electromagnetic horn including walls formed of a rigid dielectric material having an externally corrugated surface which supports a thin layer of electrical conductive material in contact therewith.

2. A horn as claimed in claim 1, and wherein the horn is hollow, and the inner surface of the dielectric material is smooth.

3. A horn as claimed in claim 2 and wherein the thickness of the dielectric material

between its smooth inner surface and the base of a corrugation is substantially the same in the region of all corrugations, and is less than the depth of a corrugation itself.

70 4. A horn as claimed in any of the preceding claims and wherein the dielectric material is a substantially lossless plastics material.

5. A horn as claimed in any of the preceding claims and wherein the electrically conductive material is copper.

75 6. A corrugated electromagnetic horn substantially as illustrated in and described with reference to the accompanying drawing.

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